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MATHEMATICS.—*A precision projection plot.* F. E. WRIGHT, Geophysical Laboratory.

For the solution of spherical triangles and of certain crystallographic-optical problems graphical methods are often used. These problems involve the angular relations between directions in space and are best presented and solved by means either of a sphere or of some projection of the sphere such as the stereographic projection. The first stereographic projection plot or net of which the writer has found record was published in 1854 as "The Great Circle Protractor" by Prof. W. Chauvenet[1] of the U. S. Naval Academy in Annapolis, Md., and was intended for use by navigators in great circle sailing and in the solution of spherical triangles. This chart consists of an equatorial stereographic projection net, 15 inches in diameter and with parallels and meridians 1° apart. A second and similar plot printed on transparent material was placed above the first net on a pivot and could be rotated about the common center. The maze of lines hereby introduced rendered, however, the application of the projection difficult and the method was not used to any great extent; it was found that tracing paper served

[1] First described in May, 1854, at the Washington meeting of the American Association for the Advancement of Science. It was adopted the same year by the U. S. Navy Department and the U. S. Naval Academy; was reissued in 1867 by the U. S. Hydrographic Office. Described also in *Great Circle Sailing*, by G. W. Littlehales. U. S. Hydrographic Office, No. 90, 1889; see also S. L. PENFIELD, Am. J. Sci. (4), **13**: 250. 1902.

the purpose better, as the observer could draw on it only those lines which he needed in his triangles.

In 1885 Commander C. D. Sigsbee[2] published a paper on Graphical Methods for Navigators in which was included an exceedingly exact stereographic projection net 18 inches in diameter. The great and small circles are drawn at 1° intervals on this net, which is the most accurate in existence. This net was issued as a separate sheet in 1888 by the U. S. Hydrographic Office.[3] Solutions with it were made commonly on a sheet of tracing paper placed above the net and rotated about the center point. Experience has shown that projection nets printed on paper suffer distortion as a result of the unequal contraction of the paper on drying. To obviate this difficulty, which may become

Fig. 1. Precision projection plot and stand.

[2] Proc. U. S. Naval Institute, **11**: 241–263. 1885.

[3] *Graphical Solution of Spherical Triangles.* By Commander C. D. SIGSBEE, U.S.N. Published December, 1888. U. S. Hydrographic Office. Plate 513. Price 40 cents. Republished in 1896 in Sigsbee's *Graphical Methods for Navigators.* U. S. Hydrographic Office.

serious when accurate measurements are to be made, R. A. Harris[4] suggested that a polar stereographic net be drawn over the Sigsbee equatorial net, so that all rotations can be accomplished directly in the projection itself and the errors due to distortion after printing be thus eliminated.

Stereographic projection nets were made use of by Fedorow[5] and Michel Lévy[6] for the representation of the optical data of the plagioclase feldspars. In 1901 Penfield[7] published an extended account of the stereographic projection and described several protractors to facilitate its practical application. In 1902 G. Wulff[8] published a stereographic net and claimed to introduce new and improved methods of using the stereographic projection; his method is commonly referred to in the literature as Wulff's method. It is of interest to note, however, that both Chauvenet and Sigsbee had published stereographic projection nets many years before Wulff and that their nets were of greatly superior precision. In view of the fact that the new method described by Wulff is identical with that which Sigsbee described many years before, it is incorrect to name the method after Wulff; if the method is to be called after its first originators it should be named the Chauvenet-Sigsbee method.

In 1906 G. W. Littlehales[9] published an atlas of many plates of a carefully drawn stereographic projection net 12 feet in diameter. By use of this net spherical triangles can be solved with an error of only 2′ in favorable cases.

Improvements in the method of mounting and rotating the projection paper were suggested by Wülfing,[10] Johannsen,[11] Wright,[12] and Noll.[13]

[4] G. W. Littlehales. *Great circle sailing.* 2d edition. U. S. Hydrographic Office, No. 90: 41–45. 1899.

[5] Zeitschr. Krist., **21**: 574–714. 1893: **22**: 229–268. 1894; **26**: 225. 1896; **27**: 337. 1897; **29**: 604. 1898.

[6] *La Determination des Feldspaths. I,* Paris, 1894; *II,* Paris, 1896.

[7] Am. J. Sci. (4), **11**: 1–24, 115–114. 1901; **13**: 245–275, 347–376. 1902; **14**: 241–284. 1902.

[8] Zeitschrift f. Kristallographie, **36**: 14. 1902.

[9] *Altitude, azimuth, and geographic position.* Philadelphia, 1906.

[10] Centralblatt für Mineralogie, 1911.

[11] Journ. Geology, **19**: 752. 1911.

[12] Carnegie Institution of Washington Publication **157**: 166. 1911.

[13] Centralblatt für Mineralogie, 380, 1912.

The device described below is similar in principle to that adopted by Wülfing, Johannsen, and Noll; but its design and construction are different; it is built with special reference to precision and convenience. A metal stand (fig. 1) supports an electric lamp at *C* which illuminates a disk of frosted plate glass; this plate in turn supports an equatorial projection net, stereographic or angle (globular), printed on thick, transparent celluloid. The two nets are 40 cm. in diameter and were reduced photolithographically by the precision methods of the U. S. Geological Survey,[14] the first from a carefully taken print of the Sigsbee projection net,[15] the second from an accurate drawing 50 cm. in diameter of an angle (globular) projection net. On both these nets, either one of which may be used, the curves are at 1° intervals and are sufficiently separated (nearly 2.5 mm. on an average) that 0.1° can be read off without difficulty. The celluloid disk rests on the glass disk and by means of centering screws can be centered to the axis of rotation of the outer steel ring which runs in an accurately turned bearing and carries the tracing paper on which the measurements are plotted in the positions indicated by the underlying projection net.

Experience extending over several years with this apparatus has shown that it meets the exacting requirements of accurate work well and is, moreover, convenient to use. The tracing paper is held in place by means of the hinged iron bars which pass over the outside square ends of the rotating ring and clamp the paper securely.

Experience has also shown that the distortion of the stereographic projection has in certain instances an appreciable effect on the attainable accuracy, and that for most purposes of calculation and of projection of optical data the angle (globular) projection net is preferable.

[14] The writer is indebted to Dr. Geo. Otis Smith, Director of the U. S. Geological Survey for having had these reproductions made.

[15] Furnished to the writer through the courtesy of Geo. W. Littlehales of the U. S. Hydrographic Office.

PHYSICS.—*The theory of the torsion and the rolling ball viscosimeters, and their use in measuring the effect of pressure on viscosity.*[1] M. D. HERSEY, Bureau of Standards. (Communicated by S. W. Stratton.)

Theory of the torsion viscosimeter. By dimensional reasoning, the torque exerted on the suspended inner cylinder, by the uniformly rotating outer cylinder of liquid, is found to be

$$T = \mu n r^3 f\left(\frac{rn^2}{g}, \frac{r^2 n}{\nu}, \text{shape}\right) \qquad (1)$$

in which μ denotes viscosity, n revolutions in unit time, r radius of inner cylinder, g gravity, and ν kinematic viscosity μ/ρ, where ρ is the density. The unknown function f may be determined empirically by varying the arguments shown, and this may be done without altering r. Three interesting cases are, first, that in which turbulence and the drag on the bottom are negligible, while the inner cylinder projects above the free surface. In this case we may calculate, approximately, the proportions for which the concavity in the free surface, due to centrifugal force, will serve to secure compensation against speed fluctuations, thus dispensing with the use of either a speed governor or a stop watch. It turns out that a large sample of the liquid will be required. The second special case is that in which the torque is not independent of the density of the sample, owing to spiral flow across the bottom or to turbulent end effects, but in which the free surface is level, so that the argument containing g in (1) drops out. In this case the instrument is self-calibrating; by observing with a single liquid what function of speed the deflection is, we can at once infer what function it is of the viscosity. Finally, a third case is that of a completely immersed cylinder, so slender that the end effects are small, and running so slowly that the final deflection is independent of the density. For this case we may integrate the equations, and

[1] This work was done at the Jefferson Physical Laboratory, Harvard University. It will later be published in detail, as a part of a more general paper on lubrication.

design the instrument so that it shall have any desired characteristics; referring to experiment only after the instrument has been set up ready for use, and then only to get a more accurate value of the single calibration constant which is required, namely τ_0, the deflection at unit speed in water.

The constants of performance of such an instrument, besides τ_0, are: the free period t; the stress in the suspension at unit deflection; the lag, or time required to attain a stated fraction of the final deflection; and the viscosity for critical damping. Of these τ_0 and t are the most important, and are given by

$$\tau_0 = 256\,\pi \frac{\mu_0}{\eta} \frac{lHr^2}{d^4} \frac{R^2}{R^2 - 1} \tag{2}$$

and

$$t = \frac{8\sqrt{2\pi}}{d^2} \sqrt{\frac{Il}{\eta}} \tag{3}$$

in which μ_0 is the viscosity of the standardizing liquid, η the shear modulus of the suspension (assumed circular; for a ribbon the coefficient 256π would give way to some larger number); l the length and d the diameter of the suspension, H the height of the inner cylinder, R the ratio of outer to inner radii, and I the moment of inertia of the suspended system. Note from (2) the insensitiveness of the instrument to changes in outer radius when the clearance is large. It is desirable that τ_0 be large, and imperative that t be small.

Construction and use. A simple form of this instrument, roughly constructed for immediate use, had the calculated values $\tau_0 = 0.32$ radian /r. p. s. in water at 20°C., and $t = 6$ sec.; and the observed values $\tau_0 = 0.38$ and $t = 5$. Deflections were read off by a pointer and graduated circle, and, subject to deviations of several per cent, were found proportional to the speed, and therefore to the viscosity. An ordinary test tube forms the outer cylinder. In changing samples, one test tube is bodily removed, and the next inserted. Thus 30 cc. is a sufficiently large sample, and the container need not be cleaned. This use of the test tube, together with the fact that the shape of the

parts permits its performance to be predicted mathematically, are the advantages of this modification over those recently used by McMichael, and by Hayes and Lewis.

The torsion viscosimeter was used to determine the viscosities of a series of liquids, ranging from water to castor oil, subsequently needed in calibrating the rolling ball viscosimeter.

Theory of the rolling ball viscosimeter. The time required for a ball to roll down a slanted tube, filled with the liquid, has been proposed and used by Flowers, who resorts to a fine bore to make roll time proportional to viscosity. In adapting this type of viscosimeter to observations under pressure, the writer has avoided the difficulties of technique accompanying small tubes, by using a large tube, for which the roll time is not proportional to the viscosity, and then determining its characteristics by dimensional reasoning.

Assuming no surface friction, some relation must subsist between the roll time t, the kinematic viscosity ν, density ρ, ball density ρ_0, gravity g, tube diameter D, ball diameter d, tube length l, angle with horizontal α, and roughness r. If so, the relation can be completely mapped out, for any one series of geometrically similar arrangements, by varying experimentally the three arguments $\frac{\nu t}{D^2}$, $\frac{gt^2}{D}$, and $\frac{\rho_0}{\rho}$. Or, without stopping to establish the complete relation, we can at once determine relative viscosities by comparing observations taken under dynamically similar circumstances; for, as long as the above arguments are kept constant,

$$\frac{\nu}{\nu_0} = \left(\frac{t}{t_0}\right)^3 = \left(\frac{D}{D_0}\right)^{3/2} \tag{4}$$

Finally, by observing the transit time τ per unit length, between two points for which the speed is sensibly constant, the three arguments above may be coalesced into two, leaving

$$F(x, y) = 0 \tag{5}$$

in which x denotes $\tau \sqrt{Dg\left(\frac{\rho_0}{\rho} - 1\right)}$ and y denotes $\nu \sqrt{D^3 g\left(\frac{\rho_0}{\rho} - 1\right)}$.

An experimental determination of this function F affords the desired calibration equation for viscosity in terms of roll time.

Experimental test of the theory. Equations (4) and (5) were verified in the course of a series of experiments in which the behaviour of the tubes was minutely studied, and the linear relation

$$y = a + bx \tag{6}$$

was found to hold over the range from $y = 0.0001$ to $y = 0.1$, the constants having the values $a = -0.0009$ and $b = +0.00027$, (subject to accidental errors of several per cent due to temperature uncertainties); provided $\alpha = 15°$ and $\frac{d}{D} = 0.63$, and that the ball and tube are of ordinary smoothness. The experiments on which the above generalized equation is based were made with a glass tube about 1 cm. in diameter, containing a $\frac{1}{4}$ inch (0.635 cm.) steel ball. Since x, y, a, and b are dimensionless, the numerical values given are common to all systems of normal units.

Construction for use under pressure. The foregoing details were duplicated, except for small corrections, in the steel tube used under pressure. This tube was fitted with electric contacts, and with pressure-tight plugs of the type developed by Bridgman, in whose laboratory the work was carried on. It was connected to the pump and gage by a considerable length of copper tubing, and swivelled so that either end could instantly be thrown up to a prescribed angle. This steel tube was calibrated for different densities by reference to equation (6).

Results on two lubricating oils. Lard oil and minera' machine oil were selected for testing, because of the well known difference in their behaviour as lubricants, although, under atmospheric conditions, they have nearly the same viscosity. Expressing the resu'ts in the form

$$\mu = \mu_0 (1 + \alpha p) \tag{7}$$

and measuring pressure in atmospheres, (kg./cm.^{2}), the value of the pressure coefficient of viscosity, α, at 20°C., was found to be 0.0023 for lard, and 0.0032 for machine oil, over a range of

200 atm. The lard oil was later carried to 500 atm., and its viscosity found to increase much more rapidly than at the lower pressures. These results point to the advisability of now mapping out the μ, p, t surfaces of all lubricants in a systematic manner. In doing so, it is possible that both the above method and the free discharge method suggested below will be found simpler than the immersed capillary tube under differential pressure, used by Faust in some recent experiments not embracing lubricants.

The extension of Poiseuille's law to high pressures. Various equations relating to lubrication might well be generalized to include the effect of pressure. Thus Poiseuille's law may be rewritten

$$Q = \frac{\pi}{8} \frac{G}{\mu_0} r^4 C \tag{8}$$

in which Q is the volume discharged in unit time, by steady isothermal stream line flow, through a tube of radius r under a pressure gradient G; μ_0 being the viscosity at the outlet pressure, and C a dimensionless coefficient depending on the viscosity-pressure curve of the liquid. Thus

$$C = \frac{\mu_0}{P - P_0} \int_{P_0}^{P} \frac{dp}{f(p)} \tag{9}$$

P_0 being the outlet, and P the inlet values of the pressure p, and $\mu = f(p)$ being some empirical formula for the viscosity. By postulating a particular form for f, we could, in theory, evaluate the coefficients therein (such as α of equation (7)), by observing the discharge from a high pressure reservoir through a long water-jacketed tube into the free air.

To determine how nearly isothermal such flow could be made, note that, when K is constant, the final temperature rise of any incompressible viscous fluid, during steady (unaccelerated) adiabatic flow, is rigorously given by the formula

$$\Delta t = \frac{\Delta p}{JK} \tag{10}$$

in which Δp is the total pressure drop, $P - P_0$, J the mechanical

equivalent, and K the thermal capacity of the liquid per unit volume. Thus the temperature rise depends solely on Δp and K; it is independent of the shape, diameter, or length of the tube, the viscosity of the liquid, or the rate of discharge.

CHEMISTRY.—*The saccharimetric normal weight and the specific rotation of dextrose.*[1] RICHARD F. JACKSON, Bureau of Standards. (Communicated by S. W. Stratton.)

Pure dextrose was prepared from starch conversion products and from invert sugar solutions. After a preliminary purging had removed a great portion of the adhering impurities, the substance was dissolved to form a 60 per cent solution in water and the crystals allowed to form slowly during continuous agitation. Two or three recrystallizations were sufficient to produce dextrose of high purity. A portion was subjected to a fractional crystallization and another portion precipitated by ethyl alcohol. The various purified samples showed essentially identical properties.

Dextrose crystallizes from water solution with one molecule of water of crystallization which it loses very readily at 60°C. The residual moisture was removed by heating in a vacuum at 60°–80°C. for several hours.

To prepare the solution for polarization, approximately the quantity required was weighed and dried in a weighed volumetric flask, and the solution was made up to the graduation mark of the flask at 20°C. From the data obtained the densities of dextrose solutions were calculated and found to correspond to the formula:

$$D\frac{20^\circ}{4^\circ} = 0.99840 + 0.003788\,p + 0.00001412\,p^2$$ where p is per cent anhydrous dextrose by weight in vacuo. The formula is valid for values of p between 5 and 30.

The solution was allowed to stand over night at room temperature in order to destroy the mutarotation.

Twelve independent measurements were made to determine the weight of substance which, contained in 100 cc. of solution,

[1] To appear in detail as a Scientific Paper of the Bureau of Standards.

would cause a rotation of 100°*S* on the scale of the quartz-wedge saccharimeter. If the latter is controlled by the conversion factors determined by Bates and Jackson,[2] namely, 34°.620 for $\lambda = 5892.5\ A$ or 40°.690 for $\lambda = 5461\ A$ or by the rotation of 26.000 gm. of pure sucrose in 100 cc., the normal weight of dextrose is 32.231 gm., weighed in air with brass weights. If the saccharimeter is calibrated by the Herzfeld-Schönrock factor, 34°.657, which Bates and Jackson have shown to be in error, the normal weight of dextrose is 32.264 gm.

For solutions more dilute than normal the rotations deviate from proportionality. It is, therefore, necessary to apply corrections, to make the scale reading indicate the per cent of substance. These corrections are given in Table 1.

TABLE 1

Reading:	90°S	80°S	70°S	60°S	50°S	40°S	30°S	20°S	10°S
Correction:	+0.20	+0.35	+0.46	+0.53	+0.55	+0.53	+0.46	+0.35	+0.20

The rotation of the normal solution (32.231 gm.) for $\lambda = 5461\ A$ is 40°.898. Since the normal quartz plate rotates 40°.690, it is evident that there is a considerable divergence between the rotary dispersion curves of dextrose and of quartz. Thus, when the quartz-wedge saccharimeter is set for a photometric match, the field is slightly heterochromatic and the degree of reproducibility of the setting is necessarily less than that of sucrose, whose dispersion curve coincides more closely with that of quartz. This difficulty is only overcome by an increased number of settings and by some preliminary experience on the part of the observer.

The specific rotation, which is a function of the concentration of dextrose, corresponds to the formula

$$[\alpha]^{20°.0}_{5461\ A} = 62.032 + 0.04257\ c$$

where c is grams of anhydrous dextrose weighed in vacuo and contained in 100 cc. of solution, or to the formula

$$[\alpha]^{20°.0}_{5461\ A} = 62.032 + 0.04220\ p + 0.0001897\ p^2$$

where p is per cent dextrose by weight in vacuo.

[2] Journ. Wash. Acad., **6**: 25. 1916; Bull. Bur. Standards, **13**: 67. 1916.

CHEMISTRY.—*Preliminary report on the system, lime: ferric oxide.* R. B. SOSMAN and H. E. MERWIN, Geophysical Laboratory.

Previous work. Apart from various isolated observations on the calcium ferrites, the only extensive investigation of the system calcium oxide: ferric oxide has been by Kohlmeyer.[1] He observed the melting and freezing temperatures of 44 mixtures, containing from 5 up to 95 molecular per cent CaO. The density and external crystal form, as well as the chemical behavior toward water, carbon dioxide, etc., of the products, were also determined. Unfortunately no optical examinations were made, and no optical properties measured.

Experience has shown that in the study of such systems as the silicates and ferrites the assistance of the petrographic microscope is almost indispensable; false conclusions may easily be reached from thermal data alone. Such was the case with Kohlmeyer's study. We have proved the existence of only one out of his five supposed compounds, while we have found one new compound, the existence of which was not shown by his thermal data.

Dissociation of the ferric oxide. A certain amount of ferrous iron is formed in all melted mixtures of CaO and Fe_2O_3. Between 50 and 100 molecular per cent CaO the percentage of ferrous oxide is small in mixtures heated to 1400°–1500°; but in melts containing from 0 to 50 per cent CaO the amount of ferrous oxide increases rapidly with the temperature and with the proportion of Fe_2O_3, so that some of the melting and solidifying points observed may actually belong in the three component system: lime-iron-oxygen. The completion of the diagram from 0 to 50 per cent CaO will therefore have to await experiments under oxygen at pressures higher than atmospheric.

Since apparatus for such experiments is not immediately available, and since the results already obtained are of some interest, particularly in connection with certain problems of Portland

[1] Diss., Berlin 1909. Ber. Deu. Chem. Ges., **42**: 4581–4594. 1909.

cement, we are publishing this preliminary report in order to make these results accessible to those interested.

It is possible that work on three component systems in which Fe_2O_3 and CaO are components, especially on the system SiO_2 – CaO – Fe_2O_3, in which quenchings can be made, will indicate changes that should be made on the accompanying CaO – Fe_2O_3 diagram, which, however, represents satisfactorily the facts so far obtained.

Method and materials. For the thermal data we depended almost entirely upon thermal curves (temperature-time curves). The method of quenching in mercury is of little avail in the system CaO – Fe_2O_3, for the reason that the products crystallize so easily and so rapidly that undercooled "glasses" are not obtained as in the case of the silicates, and the primary phase cannot, therefore, be always identified. Heating curves combined with optical examinations are, however, sufficient for the working out of the diagram. The optical properties are not as readily determinable as those of the silicates, on account of the deep colors and high indexes of refraction of the compounds, but the use of high refracting immersion glasses makes it possible to identify the phases with certainty.

Thermal curves and optical examinations were made on various mixtures of CaO and Fe_2O_3, made up initially from chemically pure $CaCO_3$ (J. T. Baker, and Baker and Adamson) and Fe_2O_3 (Baker and Adamson, and Kahlbaum). Charges of from 1.0 to 2.5 grams were used, in small platinum crucibles in a platinum-wound furnace. The carbonate-oxide mixtures were first melted down and then ground and re-melted for the determination of the thermal breaks. The mixtures containing less than 50 molecular per cent CaO were not heated above 1250°, to avoid, as far as possible, dissociation of the Fe_2O_3. Temperatures were measured by the platinum-platinrhodium thermoelement and potentiometer.

The composition-temperature diagram. We find only two binary compounds in the system CaO – Fe_2O_3. These are: (1) the 1 : 1 compound, $CaO.Fe_2O$; (2) the 2 : 1 compound, $2CaO.Fe_2O_3$. Both of these appear to be dissociated at their melting points.

The melting point of *pure CaO* is 2570°, according to Kanolt.[2] Its properties have been published elsewhere.[3]

The "transition temperature" at which the compound $2CaO.Fe_2O_3$ dissociates and is in equilibrium with CaO and liquid is 1436°. All mixtures from about 64 molecular per cent (about 38 weight per cent) of CaO up to pure CaO liquefy in part at this temperature, leaving pure CaO as the solid phase in excess. This

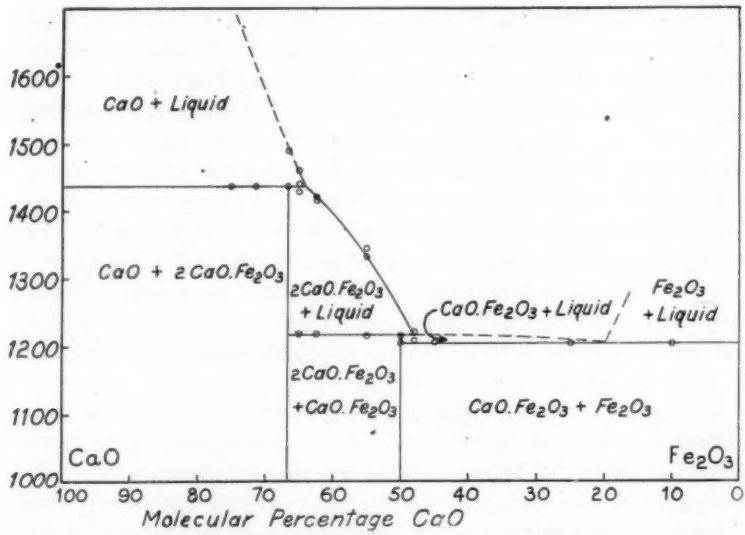

Fig. 1. Composition-temperature diagram of the system CaO-Fe_2O_3. Circles represent observed thermal breaks.

forms relatively large, rounded, clear grains, which dissolve as the temperature is raised, until they disappear completely at the temperature of the liquidus curve.

The compound $2CaO.Fe_2O_3$ crystallizes well, giving black crystals which are of a yellowish brown color by transmitted light under the microscope. The liquid can be undercooled to 1385°

[2] This JOURNAL, **3**: 315–318. 1913.

[3] RANKIN AND WRIGHT. Am. Journ. Sci., **39**: 3. 1915.

or lower. The crystallized product then shows traces of free CaO and $CaO.Fe_2O_3$, which are due to dissociation, and which have not combined during cooling. The compound forms from a finely powdered mixture of $CaCO_3$ and Fe_2O_3 at a temperature considerably below its liquefying point; under our conditions a considerable quantity of the compound formed during 30 minutes heating at 1000°, although none was visible in a mixture heated rapidly to 950°, at which temperature most of the carbon dioxide had been expelled.

The optical properties of the compound $2CaO.Fe_2O_3$ are: biaxial, positive, with a moderate optic axial angle. $\alpha_{Li} = 2.200 \pm 0.005$, $\beta_{Li} = 2.220 \pm 0.005$, $\gamma_{Li} = 2.290 \pm 0.005$. The optical dispersion of α is the same as of the immersion medium, therefore α_{Na} is about 2.25; β and γ have lower dispersion. α is absorbed considerably through the red as well as for shorter wave-lengths. β and γ are absorbed little at wave-lengths longer than $620\mu\mu$, and are transmitted considerably at $550\mu\mu$.

There is no optical evidence of solid solution either of CaO or of $CaO.Fe_2O_3$ in the compound.

The transition temperature at which the compound $CaO.Fe_2O_3$ dissociates, and is in equilibrium with liquid and with $2CaO.Fe_2O_3$ is 1216°. All mixtures between about 48 and 65 molecular per cent of CaO (about 24.5 to 38 weight per cent) liquefy in part at this temperature, forming liquid and leaving excess of $2CaO.Fe_2O_3$ as the crystalline phase, which dissolves with rising temperature and disappears at the liquidus curve.

The compound $CaO.Fe_2O_3$, after dissociating and nearly all liquefying at 1216°, becomes completely liquid at about 1250° by the disappearance of the solid $2CaO.Fe_2O_3$ formed by dissociation. The liquid crystallizes with less undercooling than does the compound $2CaO.Fe_2O_3$, and the temperature of the thermoelement sometimes rises to within a few degrees of 1216°. The crystallized product contains an appreciable amount of $2CaO.Fe_2O_3$, and dark dusty ferric oxide. When powdered and reheated at 1190°, these dissociation products recombine completely, forming a homogeneous product of red $CaO.Fe_2O_3$; the powder also sinters together.

The compound forms from a finely powdered mixture of $CaCO_3$ and Fe_2O_3 at a temperature well below the melting point, just as the 2 : 1 compound does. It crystallizes well, giving black crystals. The crystals are frequently in the form of long needles,[4] but no evidence of prismatic habit is visible in the powdered preparation under the microscope.

The optical properties of the compound $CaO.Fe_2O_3$ are as follows: *Color:* deep red, about like hematite; *optical character:* nearly or quite uniaxial, negative; *indexes of refraction:* $\omega_{Li} = 2.465 \pm 0.005$, $\epsilon_{Li} = 2.345 \pm 0.005$. For sodium light ω is about 2.58 and ϵ about 2.43. These values were determined by observing that throughout the red and orange the dispersion of the compound was not noticeably different from that of the immersion medium. ϵ is absorbed slightly more than ω in the orange and at shorter wave-lengths, but not noticeably more in the red. Grains 0.01 mm. in thickness show scarcely any absorption at wave lengths longer than $610\mu\mu$; at wave lengths shorter than $580\mu\mu$ they are very dark.

There is no optical evidence of solid solution either of $2CaO.Fe_2O_3$ or of Fe_2O_3 in the compound.

There is a *eutectic* at 1203° between $CaO.Fe_2O_3$ on the one hand, and ferric oxide (hematite) on the other. The mixture containing 10 molecular per cent CaO shows clearly an excess of hematite. The mixture with 25 molecular per cent CaO consists almost entirely of a deep red, apparently homogeneous, material, which is probably an intimately intergrown eutectic of $CaO.Fe_2O_3$ and Fe_2O_3; the mixture contains also a little excess of red $CaO.Fe_2O_3$. The eutectic composition is therefore between 10 and 25 per cent CaO, and probably near the latter.

The melting point of *pure* Fe_2O_3 is unknown, as it dissociates under atmospheric pressure of oxygen before the melting point is reached into oxygen and a solid solution of Fe_3O_4 in Fe_2O_3.[5] Its optical properties have been published elsewhere.[6]

[4] See photographs by Hofman and Mostowitsch, Bull. Am. Inst. Min. Eng. **39**: 628–653. 1909.

[5] SOSMAN AND HOSTETTER. Jour. Am. Chem. Soc., **38**: 807–833. 1916.

[6] MERWIN. Jour. Am. Chem. Soc., **38**: 830. 1916.

The Fe_2O_3 fragments in the preparation containing 10 molecular per cent CaO, which had been heated to 1250° but was not completely melted, had a variable and lower refractive index than pure hematite (ω as much as 0.05 lower). This is due to solid solution either of $CaO.Fe_2O_3$ or of Fe_3O_4. ω was measured in an amorphous mixture of selenium and arsenic selenide (As_2Se_3), by means of which, with the addition of tellurium, a refractive index of about 3.15 for red can be reached.

We have found no evidence as yet of a 3 : 1 compound analagous to tricalcium aluminate. Samples of this composition quenched[7] after 15 minutes at 1575°, 15 minutes at 1525°, 15 minutes at 1325°, and 3 hours at 1375° all consisted only of CaO and $2CaO.Fe_2O_3$. Thermal curves on this mixture showed only the melting at 1434–1436°.

Chemical analogy has naturally led several authors to expect a phase rule diagram for the system $CaO - Fe_2O_3$ similar to that for $CaO - Al_2O_3$. Campbell,[8] for instance, assumed the existence of the compound $5CaO.3Fe_2O_3$, analogous to the 5 : 3 compound of lime and alumina, and claimed to have found chemical evidence for its existence. We find no evidence of such a compound. Instead of being analogous to $CaO - Al_2O_3$, the diagram of the system $CaO - Fe_2O_3$ resembles that of $MgO - SiO_2$[9] much more clearly than it resembles that of any other of the silicate systems with which we are familiar.

PLANT MORPHOLOGY.—*Morphology and evolution of leaves.* O. F. Cook, Bureau of Plant Industry.

In seedlings of many palms, grasses, and other plants the first leaves are simple, bladeless sheaths, or the blade appears as an appendage or expanded outgrowth from the rim of the sheath. Leaves with larger blades are produced as the plant grows, until the adult degree of specialization is attained. The essential feature of the primitive leaf is the basal sheath, in the form of a

[7] Quenchings by G. A. Rankin.
[8] E. D. Campbell. Jour. Ind. Eng. Chem., **7**: 835–837. 1915.
[9] N. L. Bowen. Am. Jour. Sci., **37**: 487–500. 1914.

cylinder. Each sheath in turn encloses the terminal bud of the shoot, and later encircles the stem.

Three elements of leaf structure—blade, petiole, and stipules—are recognized generally in manuals and textbooks. These are convenient for purposes of description, but for understanding the structure and evolution of leaves it is better to begin with the sheath or with the sheath and the blade, the two elements that appear to have been differentiated in advance of the others. Sheaths have been looked upon as expanded petioles or united stipules, instead of being considered as a primitive element. It has seemed reasonable to suppose that the petiole and the stipules have been derived from the blade, which in most plants is the largest and most important part of the leaf, but a general interpretation in accord with evolutionary facts is needed in the study of structural variations of plants.

THE PRIMITIVE FUNCTION OF LEAVES

In plants like *Equisetum*, *Ephedra*, and *Casuarina* the internodes perform the vegetative functions. Leaves are represented only by sheaths or scales which are mere appendages of the internodes, apparently of little use except for protecting the buds. Palms and many other plants afford examples of internodes and sheaths that have chlorophyll and stomata in the epidermal tissues and share the vegetative functions with the blades of the leaves. Cacti and specialized desert plants of other families have very small or rudimentary leaves, thus reducing transpiration.

It is customary to think of bud scales and similar organs as leaves that have been specialized by reduction, but it may be more correct morphologically to think of foliage leaves as enlarged bud scales that have assumed the vegetative functions formerly discharged by the internodes. The function of the bud scales is older than are the present forms of leaves, and may date back to the stage when the sheaths were simple cylinders, before the development of more specialized forms of leaf structure. It is unnecessary to suppose that the early types of seed plants lacked bud scales.

THE COURSE OF SPECIALIZATION IN LEAF-FORMS

Other specialized forms of leaves, such as sepals, bracts, and scales of subterranean rootstocks, may also be considered as representing primitive sheaths or bud scales, rather than as reductions from the fully developed type of foliage leaves. From this point of view the foliage leaves appear to be the most specialized. Yet in developing the foliage leaves plants have not lost the ability to produce the simpler organs—sheaths, bud scales, or bracts. The plant body is a succession of different kinds of internodes, or metamers, bearing different kinds of leaves. At one end of the series are the cotyledons or seed-leaves, at the other the carpels or fruit-leaves, with many intermediate stages between the different kinds of foliar and floral organs.

As stamens are often transformed into petals, so we may think of cotyledons and foliage leaves as sterile carpels performing vegetative functions. Some of the species of *Sterculia* have broad leaflike carpels that persist and remain green long after the seeds have been shed. That the stamens and carpels of the different families of plants are generally more alike than the leaves or other parts of the plant body is more easily understood when we consider the evolution of plants as a process of intercalation of more numerous and more specialized forms of metamers. Plants like the junipers, pines, and eucalypts have two distinct kinds of foliage leaves, showing clearly that a double evolution of these organs has taken place.

The succession of different kinds of leaves, the classical example used by Goethe in presenting the idea of evolutionary changes in the forms of the same organ, may not be less significant for the strictly morphological purpose of understanding the origin and homologies of the structural elements of the leaves. The changes that take place in passing through the succession of leaf-forms, during the development of the plant, are also of interest for the study of heredity.[1]

[1] Cook, O. F. *Dimorphic leaves of cotton and allied plants in relation to heredity.* U. S. Dept. Agric., Bur. Pl. Ind., Bull. 221. 1911. *Heredity and cotton breeding.* U. S. Dept. Agric., Bur. Pl. Ind., Bull. 256. 1912.

DIFFERENTIATION OF THE LIGULE

In the development of foliage leaves the ligule was probably the first structure to be added after the sheath and the blade. The ligule may be described as a thickened rim of the leaf sheath, bearing the weight of the blade or holding the sheath in place around the stem. In *Serenoa* and related genera of fan-palms the ligule is supplemented by a ligule-like expansion of the rim that supports the bases of the segments on the under side of the leaf. Although these subligules, as they may be called, appear in only a few palms, they are not without general interest as organs that are closely parallel in structure and function with the true ligules.[2]

The sheaths of most palms are thickened on the side that supports the petiole, and are split on the opposite side, allowing the leaf to diverge more widely from the trunk, but the more primitive condition of closed sheaths with nearly uniform texture is also found, as in *Calamus*, *Desmoncus*, and *Chamaedorea*. Even in the large royal palms and many others the sheaths are not split until the leaves are ready to fall.

In palms like *Desmoncus* and *Pyrenoglyphis*, as in many members of the family Polygonaceae, the sheath, instead of being specialized at the mouth to form a ligule, is prolonged far above the insertion of the petiole, forming what is known as an ocrea. A similar prolongation of the sheath beyond the point of attachment with the petiole is found in the bud scales of *Magnolia* and *Ficus*. Some writers have taken it for granted that the ocrea, or the entire sheath, has been formed by the union of stipules, but the indications point rather to the formation of stipules by reduction and specialization of the sheaths of the more primitive forms of leaves.

Whether we consider that the blade arose simply as an expansion of the upper portion of the sheath or as an outgrowth from the rim of the sheath, the ligule may be considered as marking

[2] My attention has been called by Mr. H. Pittier to illustrations of the subligule of *Trithrinax campestris* published by C. De Candolle, Bull. Soc. Bot. Genève, II. **5**: 106, pl. 3. 1913.

a line of separation of the two portions of the primitive leaf that became specialized. Even this indication of definite specialization of parts is lacking in many plants, as among the lilies, orchids, and plantains, where the leaves still appear as simple sheaths with a gradually broadened distal portion to serve as a blade, but no distinct separation of special parts. The idea of leaf blades arising as outgrowths from leaf sheaths appears more probable, or at least less fantastic, when we consider such a case as the leaf of *Smilax*, where the end of the sheathing base produces a pair of slender tendrils several inches in length, in addition to the blade of the leaf. It may not be without significance that rudimentary blades of abnormal or reduced leaves often assume very slender, tendril-like forms.

THE EVOLUTION OF STIPULES

It has been supposed that stipules were developed from basal lobes of leaf blades. This interpretation was suggested by Ward and later adopted by Berry on the basis of evidence drawn from fossils and abnormal leaf-forms of *Liriodendron*, but these can be understood as intermediate stages between normal leaf-forms and bud scales. It seems unnecessary to suppose that stipules began with *Liriodendron*, or that the stipules of *Liriodendron* are not homologous with those of other genera and families.[3]

The very general occurrence of stipules or stipular structures is in itself a fact that must make it difficult to credit the idea of recent development or independent derivation of such organs, either in the family Magnoliaceae or in the many and widely different families of plants that have stipules. The stipules of *Liriodendron* may be more primitive than those of other Magnoliaceae in retaining more of the vegetative functions of the primitive sheath, but their nearly complete separation from the petiole and from each other may be considered as a specialization, since partially united stipules occur. Union between the stipules and the petiole is shown in many of the reduced leaves or the large floral bud scales that have small petioles and blades. Union

[3] BERRY, E. W. *The origin of stipules in Liriodendron.* Bull. Torrey Bot. Club, **28**: 493. 1901.

between the stipules on the side opposite the petiole is sometimes shown in very large stipules of strong shoots.

Another line of evidence tending to throw doubt on this idea of stipules as specializations of leaf blades might be drawn from bracts and other organs that take the form of sheaths, even in families whose normal foliage leaves are without stipules. Thus, in the genus *Hicoria* the outer scales of lateral buds have the form of a closed sheath, carinate on each side, somewhat similar to the prophylla of grasses and palms. The large membranous bud scales that precede the leaves on new shoots of *Hicoria* also represent sheaths and sometimes appear in modified form as stipular wings of the petiole, on abnormal leaves of shoots developed late in the season.

Considerations drawn from the study of "nodal anatomy" have been used recently by Sinnott and Bailey as the basis of interpretation of leaf morphology. Stipules, sheaths, and ligules are classed together as "modifications of the base of the petiole," the final conclusion being that "a leaf with two distinct stipules is more ancient in type than one with a sheathing base."[4]

Stipules have also been considered as "accessory leaves," or as a specialized development of the basal portion of the "true petiole."[5] In the present view, stipules, bud scales, and various forms of bracts appear to have been derived not from the blade or the petiole of specialized leaves, but from the primitive sheath. The ligule and even the blade itself are considered as specializations from the distal end of the sheath; but scales and stipules as specializations of the basal portion. Petioles are not all homologous, but are of two kinds, some derived from the sheath, and others from the blade.

THE TWO KINDS OF PETIOLES

Taking account of the ligule or the ocrea as marking the end of the primitive sheath makes it possible to distinguish very

[4] SINNOTT, E. W., and BAILEY, I. W. *Investigations on the phylogeny of the angiosperms. 3. Nodal anatomy and the morphology of stipules.* Amer. Journ. Bot., **1**: 441–453, pl. 44. 1914.

[5] See, TYLER, A. A. *The nature and origin of stipules.* Ann. N. Y. Acad. Sci., **10**: 1–49, pls. 1–111. 1897.

clearly the two kinds of petioles. Both kinds are represented among the palms. In fan-palms the so-called petiole is below the ligule, whereas the part described as petiole in some of the pinnate-leaved palms certainly is above the ligule or ocrea. In the fan-palms it is plain that the petiole is a narrowed, elongated portion of the leaf sheath, ending at the ligule, whereas the petiole of the Cocaceae and Chamaedoreaceae represents a naked basal portion of the rachis or midrib.[6]

That the petioles are of two kinds is apparent also from the fact that in the fan-palms the petioles agree in structure and are entirely continuous with the leaf sheath, while in the pinnate-leaved palms there is equally complete agreement and continuity with the rachis. But the leaf structure is not the same in all of the pinnate-leaved families. There appear to have been several independent derivations of pinnate leaves from fan-leaved ancestors. The Geonomaceae are a pinnate-leaved family in which the petiole appears to be a part of the sheath, the same as in fan-palms.

The magnolia family affords another example of double differentiation of the petiole, the lower part of the organ being formed by a thickened segment of the leaf sheath, while the upper part is a narrowed base of the blade, as shown by the decurrent margins which run down to the ligule. In such species as *Magnolia virginiana* the lower portion of the petiole is marked very distinctly by the scar of the deciduous leaf sheath, with a minute hairy prominence at the end, which may be considered as a thickened base of the ligular prolongation that forms the apex of the sheathing bud scale.

It is conceivable that a petiole formed originally from the sheath element might become separated from the remainder of the sheath, which would account for the evolution of such organs as the deciduous bud scales of the Artocarpaceae. But all petioles formed from sheaths would remain essentially different morphologically and developmentally from those that were formed originally as basal elongations of the midrib of a simple

[6] Cook, O. F. *Origin and evolution of angiosperms through apospory.* Proc. Wash. Acad. Sci., **9**: 174. 1907.

leaf, or by moving the pinnae farther up the rachis of a compound leaf, as in the pinnate palms.

SHEATH PETIOLES AND BLADE PETIOLES

The recognition of the two kinds of petioles as representing distinct morphological elements makes it necessary to have more convenient ways of designating the two classes of organs to which the word petiole has been applied indiscriminately. The use of such terms as *sheath petiole* and *blade petiole* would afford a way of indicating the distinction. Sheath petioles would be understood as those that represent specializations of the primitive sheath, and blade petioles as specializations of the blade or midrib of the leaf.

Other terms that might be used are *infraligular* for the sheath petioles and *ultraligular* for the blade petioles, in allusion to the differences of position in relation of the ligule. It might be objected that ligules are confined to a few families, but the terms would still serve to indicate the homologies of the parts to those of plants whose possession of ligules gives the most definite basis for the distinction between the two kinds of petioles.

THE FOOT AS A NEW ORGAN

For general descriptive purposes and especially for dealing with plants in which the resemblance to the primitive sheath has entirely disappeared, it may be simpler to treat the petiole-like sheath element as a new organ not formally distinguished hitherto. On this basis instead of *sheath petiole* or *infraligular petiole*, a single word like *foot*, in Latin descriptions *pes*, might be used. This would have the advantage of leaving the term petiole as nearly as possible in its present signification, which would need to be modified only in those cases where the so-called petiole might be found to represent the sheath element. No doubt there are many plants where not only the stipules are lacking, but also the foot.

From this point of view it would be possible in dealing with different families of plants to define the foot in any way that might be most convenient, as a thickened segment of the primitive sheath, as the element of the primitive sheath that supports

the blade, as the element that is between the petiole and the internode, or as the element to which the stipules are attached. Thus in the peaches, almonds, plums, and other members of the family Amygdalaceae, the petiole is articulated at its base to the foot, to which the stipules are attached. The petiole is deciduous with the blade, but the foot persists for another season and functions as a bud scale. The foot is present also in apples, pears, and roses, but falls with the leaf, there being no joint at the base of the petiole.[7] The joint is present in Oxalis and in many leguminous plants.

Objection might be taken on etymological grounds to using the word *foot* for an element that in many plants is smaller than the petiole, which term means a small foot. It does not seem, however, that this is likely to cause confusion, since the obvious signification of foot is in relation to the lowest, most truly basal portion of the leaf. Absence of the foot is to be considered as a specialization of leaf structure, and it will be interesting to determine the status of the organ in the different families. Even though not present in the foliage leaves, the foot may still be represented in the bud scales, bracts, or other organs which from our present point of view appear to be more primitive and less specialized than the foliage leaves. That the cotyledon is sometimes called the nursing foot, or simply the foot, hardly constitutes an objection to the use of this word, with other leaves, for the element that corresponds to the cotyledons and primitive bladeless sheaths of seedlings.

PULVINI AND ARTICULATIONS

Pulvini and articulations represent special forms of tissue connected with the ligule or base of the blade in grasses and palms, and found in corresponding positions in other families of plants. The chief function of pulvini is to control the position of the leaf blade, which is accomplished by varying the turgidity or water pressure in the rather loose cells of which the pulvini are composed. A flexible pulvinus is in the nature of a joint.

[7] Cook, O. F. *Jointed leaves of Amygdalaceae.* Journ. Wash. Acad. Sci., **2**: 218–220. 1912.

Many leaves have a basal pulvinus, with a layer of absciss tissue to form an articulation with the internode, when the leaf separates at maturity. In other leaves the joint that provides for the detachment of the leaf is between the foot and the petiole, as in the case of the peaches, plums, cherries, and related plants. In *Magnolia virginiana* there is a pronounced development of the entire upper surface of the foot as a pulvinus, which has a special function in lifting the winter bud scales in the spring.

The organ that is usually described as a true petiole may prove to be a foot in cases where there are pulvini at both ends, as in cacao. In the patashte tree, a relative of cacao, the petioles of the leaves of the fruiting branches have the structure of pulvini for their whole length.[8] In the cotton plant also there are pulvini at both ends of the petiole. Other reasons for considering the cotton petiole as a foot may be found in the fact that while the margins of the leaf blade never show any tendency to become decurrent, the petiole is often united with the margins of enlarged stipules like those that form the involucral bracts.

The suppression or extreme reduction of the blade in the formation of the involucral bracts of the cotton plant might also be considered as an indication that the blade, in spite of its much greater size, still behaves in some respects as an appendage of the sheath. That the general course of evolution has been in the direction of enlarging the blade and reducing the sheath element may be considered as at least a partial explanation of the fact that enlargement of the stipules is almost invariably accompanied by reduction of the blade of the leaf. If only one stipule is enlarged, a lobe is likely to be wanting on the same side of the blade.[9]

SUMMARY

The leaves of angiosperms show a primary division into two morphological elements, (1) a basal sheath supporting (2) an expanded blade, as represented in the leaves of palms, grasses, and many other plants. The organs that are usually described

[8] Cook, O. F. *Branching and flowering habits of cacao and patashte.* Contr. U. S. Nat. Herb., **17**: 609–625, pls. 44–54. 1916.

[9] Cook, O. F. *Brachysm, a hereditary deformity of cotton and other plants.* Journ. Agric. Research, **3**: 387–400, pls. 53–62. 1915.

as petioles are of two kinds, (1) some that appear to have arisen through a narrowing of the base of the blade, and (2) others through a narrowing of the primitive sheath. The name foot is suggested for a specialized portion of the leaf sheath that serves as a petiole. Both the petiole and the foot are represented in many plants, in such families as the Amygdalaceae, Rosaceae, and Magnoliaceae. Stipules, bud scales, bracts, ligules, and pulvini are other specializations of the primitive sheath element, and the blade also appears to have arisen as an outgrowth or expansion of the sheath.

ETHNOBOTANY.—*Identity of cohoba, the narcotic snuff of ancient Haiti.*[1] WILLIAM EDWIN SAFFORD, Bureau of Plant Industry.

The natives of Hispaniola, or Haiti, at the time of the Discovery made use of a narcotic snuff, which they inhaled through the nostrils by means of a bifurcated tube. This snuff induced a kind of intoxication or hypnotic state, accompanied by visions, which were regarded by them as supernatural. While under its influence the necromancers, or priests, were supposed to hold communication with unseen powers, and their incoherent mutterings were regarded as prophesies or revelations of hidden things. The same practice was also followed by their physicians in treating the sick, in order to ascertain the cause of maladies and to determine remedies which should be used for their cure. This snuff was called in the language of the islanders "coxoba" (the sound of the *x* approaching that of the German *ch*, or the guttural Spanish *j*). In Spanish orthography the word was written "cojoba," and in Italian "cogioba," a form which has been incorrectly transcribed "cogiba" and "cojiba." These various forms of the word might lead to confusion, were it not for the fact that Las Casas clearly indicates its pronunciation, as follows: "These powders and these ceremonies, or acts, were called *cohoba*, the middle syllable long in their language, in which they pronounce as in the Arabic, or like the Germans confusedly."[2]

[1] Published with the permission of the Secretary of Agriculture.

[2] LAS CASAS. Apolog. Hist. de las Indias, Chapt. 166, pp. 445–446, ed. Serrano y Saenz, Madrid. 1909.

FIG. 1. Cohoba, *Piptadenia peregrina* (L.) Benth., the source of the narcotic snuff of Hispaniola. Natural size.

By nearly all authors who have written of ancient Haiti or on the history of tobacco, *cohoba* snuff has been confused with tobacco, and the bifurcated snuffing tubes have been mistaken for nose pipes used for smoking. This confusion can be traced to Oviedo, whose account of tobacco is misleading and incorrect. Oviedo, indeed, is responsible for many mistakes that have been handed down from writer to writer. His statements are often contradictory, and not infrequently he confesses that he writes from memory or from the testimony of others. In his first work, *De la natural hystoria de las Indias* (1526), he does not mention either *cohoba* or tobacco, in connection with the natives of Hispaniola. In his *Historia general de las Indias* (1535) he says nothing of snuff but speaks of the evil custom of taking certain fumigations, which the Indians call tobacco, in order to lose their senses; "and this they did with the smoke of a certain herb, which, according to what I have been able to learn, is of the quality of hen-bane [Hyoscyamus] but not resembling that plant in form and habit;"[3] and he further states that the smoke was inhaled through certain canes with two tubes, of which he presents a Y-shaped figure, which, like his description of the method of using them, was certainly drawn, not from his personal observation, but from the descriptions of others. Oviedo, unfortunately, has been quoted by many authors, and his Y-shaped figure, with its branches so diverging that they could not possibly have been simultaneously inserted in the nostrils of a human being, has been copied again and again.[4]

EARLIEST ACCOUNTS OF COHOBA

The ceremonial use of *cohoba* is described in the very first work which treats of the ethnology of the New World, written in 1496

[3] "Usavan los indios desta isla entre otros sus vicios uno muy malo, que es tomar unas ahumadas que ellos llaman tabaco para salir de sentido: y esto hazian con el humo de cierta yerva, que a lo que yo he podido entender es de calidad del veleño: pero no de aquella hechura o forma a la vista." OVIEDO, op cit., fol. xlvii. 1535.

[4] Among the earliest writers to cite Oviedo was Purchas, who states that the natives of Hispaniola "had tobacco in religious veneration, not only for sanity, but for sanctity also, as Oviedo writeth, the smoke whereof they took into the nose

by Ramon Pane, who accompanied Columbus on his second voyage. This paper, originally in Spanish, is best known through an Italian translation published as an appendix to the *Historie* of Fernando Colombo (1571), now a rare work, a copy of which is in the Library of Congress. The author, whose name appears in the introduction as "Frate Roman, povero Eremita del l'ordine di San Gieronimo," wrote, in obedience to the command of the illustrious Lord Admiral and Viceroy, what he was able to learn concerning the beliefs and idolatry of the Indians. In describing their snuff he calls it in one place *cohoba* and elsewhere *cogioba* (Italian orthography, like "*Gieronimo*," quoted above). Writing in the present tense, he says: "This powder they draw up through the nose, and it intoxicates them to such an extent that when they are under its influence they know not what they do."[5] In striking contrast to Oviedo, Fra Ramon wrote only what he had actually seen, and he confined the field of his observations to the natives of the island of Hispaniola, stating: "Color, de' quali ciò scrivo, son dell'Isola Spagnuola; percioche delle altre Isole io non so cosa alcuna, non havendo mai veduto."[6]

Peter Martyr's account of the inhabitants of Hispaniola, in his *De Orbe Novo*, is simply a paraphrase of Fra Ramon's paper, in Latin. It adds nothing to his description of *cohoba*, but on the other hand it is misleading, since it refers to it as "an herb which they pound up and drink;" and though it states that the natives "absorb the intoxicating herb called cohobba, which is the same as that used by the bovites to excite their frenzy," it fails to

with a forked pipe fitted to both nostrils, holding the single end in the smoke of that herb burning in the fire until they became senseless. Their priests most used this, who, coming to themselves after this sleepy fume, delivered the oracles of their zemes or devils, which sometimes spake by them."—*Purchas, His Pilgrimage*, **5**: 957. 1626. Among the latest authorities to be misled by Oviedo is H. Ling Roth; see his account of tobacco in *The aborigines of Hispaniola*, in Journ. Anthrop. Inst. **16**: 258. 1887. See also, BOURNE, EDWARD GAYLORD, in Proceedings of the American Antiquarian Society of Worcester, n. s., **17**: 327. 1906; and FEWKES, J. W., in Twenty-fifth Ann. Rept. Bur. Amer. Ethn., 630. 1907.

[5] "Una certa polvere, chiamata Cohoba, tirandola a se per il naso, la quale gli imbriaga de tal maniera, che non sanno quel, che si fanno."—RAMON PANE, (1496), in appendix to Fernando Colombo's *Historie*, cap. XV, f. 134. 1571.

[6] RAMON PANE, op. cit., f. 126. 1571.

specify that they breathed it through their nostrils by means of a forked tube. Nothing is said of the apparatus by which the snuff is taken, and indeed Ramon Pane himself neglects to give a description of it. Fernando Colombo, however, in the work already cited, states that for holding the snuff the natives had a finely wrought table of a round form, resembling a trencher (*come un tagliere*), and that they took it by means of a bifurcated tube: "*con una canna di due rami, che si mettono al naso.*"

The description of Las Casas, who was an eye-witness to the ceremony of the cohoba, is even more precise. The snuff-tray he describes as "a plate, not flat but slightly concavish or deep, made of wood, so handsome, smooth, and pretty, that it could not be very much more so, were it made of gold or silver; it was almost black and polished like jet" (*cuasi negro y lucio como de azabache*). The tube, he says,

was fashioned the size of a flute and was quite hollow like a flute. From two-thirds of its length onward it divided by means of two hollow canes, just as we open the two middle fingers, leaving out the thumb, with the hand extended. The ends of these two canes inserted into the windows of the nostrils, and the base of the flute, let us say, into the powder on the plate, they would draw in their breath and snuffing up, would receive through the nostrils as much of the powder as they wished to take, which, when taken, would go at once to the brain, almost as though they had drunk strong wine; for they would become drunk or almost drunk. . . . . It was their custom, in coming together to decide difficult matters, such as the manoevures of one of their war parties, or the performance of other things which they deemed important, to make their cohoba and with it intoxicate themselves or nearly so to do. . . . . I saw these people on several occasions celebrate their cohoba, and it was an interesting spectacle to witness how they took it and what they spake. The Chief began the ceremony, and while he was engaged all remained silent. When he had taken his cohoba (that is, when he had snuffed up the powder through his nostrils, as I have described), they being seated on certain handsomely carved low benches which they called *duohos* (the first syllable long), he remained silent for a while with his head inclined to one side and his arms placed on his knees. Then he raised his face heavenward uttering certain words which must have been his prayer to the true God, or to him whom he held as God; after which all responded, almost as we do when we say *Amen;* and this they did with a loud voice or sound. Then they gave thanks and said to him certain complimentary things, entreating his benevolence and begging him to reveal to them what he had seen. He described to them his vision, saying that the *Cemi* had spoken to

him and had predicted good times or the contrary, or that children were to be born or to die, or that there was to be some dispute with their neighbors, and other things which might come to his imagination, all disturbed with that intoxication; or if perhaps without it, what the devil, to deceive them and win them to his worship, had brought to them.[7]

The snuff itself was described by Las Casas as "finely ground and of the color of cinnamon or powdered henna" (*de color de canela ó de alheña molida*).[8]

THE COHOBA TREE STILL PERSISTS IN HAITI

That a substance with the intoxicating effects of *cohoba* should have been identified with tobacco seems strange; but if not tobacco, what could have been its origin? Is the custom of taking a narcotic snuff by means of a bifurcated tube still in existence in any part of America? If so, from what plant is the snuff prepared, and is this plant to be found growing on the island of Haiti? These questions may be answered as follows: The custom of taking a narcotic snuff still prevails in various localities of South America, showing that at one time it must have been widely spread. In inhaling it some tribes used bifurcated tubes which correspond very closely with the descriptions of those used in Hispaniola. The plant from which the snuff is derived is *Piptadenia peregrina*, a tree which grows both spontaneously and in cultivation on the banks of the Orinoco and Amazon Rivers and their tributaries. This tree does grow on the island of Hispaniola, or Haiti, as well as upon the neighboring island of Porto Rico and several other of the Antilles; and—most interesting and convincing of all facts connected with it—it still bears the name *cohoba*, which was applied in ancient times both to the snuff itself and to the ceremonial practice of using it.

[7] Las Casas. Apol. Hist. de las Indias, Chapt. 166, pp. 445–446, ed. Serrano y Saenz, Madrid. 1909.

[8] Alheña is the name of the so-called Egyptian privet, *Lawsonia inermis*, the powdered leaves of which, called henna, were used by the Egyptians for coloring their finger-nails. The fragrant flowers of this plant are the principal source of the perfume wafted by the breezes of "Araby the Blest."

NARCOTIC SNUFFS OF SOUTH AMERICA

It was in connection with his studies of the economic plants and plant products of the aborigines of America that the writer came upon a description of the custom of snuff-taking by certain tribes of Indians inhabiting the tributaries of the Orinoco, in Padre Gumilla's *El Orinoco Ilustrado*, printed in Madrid in 1741. In describing the customs of the Otomaco Indians this venerable missionary bewails their use of inebriants, as follows:

> They have another most evil habit of intoxicating themselves through the nostrils, with certain malignant powders which they call *yupa*, which quite takes away their reason (*que les quita totalmente el juicio*), and furious, they grasp their weapons; and if the women were not adept at seizing and tying them, they would commit cruel havoc every day; this is a tremendous vice. They prepare this powder from certain pods of the *yupa* (*unas algarrobas de yupa*) from which the name is derived, but the powder itself has the odor of strong tobacco. That which they add to it, through the ingenuity of the devil, is what causes the intoxication and the fury. After eating certain very large snails which they find in the inundated areas along the river they put their shells into the fire and burn them to quicklime whiter than snow itself. This lime they mix with the *yupa* in equal quantities, and after reducing the whole to the finest powder there results a mixture of diabolical strength; so great, that in touching this powder with the tip of the finger, the most confirmed devotee of snuff cannot accustom himself to it, for in simply putting his finger which touched the *yupa* near to his nose, he bursts forth into a whirlwind of sneezes. The Saliva Indians and other tribes of which I shall later treat also use the *yupa*, but as they are people gentle, benign, and timid, they do not become maddened like our Otomacos, who, even on account of this, have been and still are formidable to the Caribs; for before a battle they would throw themselves into a frenzy with *yupa*, wound themselves, and full of blood and rage (*llenos de sangre y de saña*) go forth to battle like rabid tigers."[9]

Shortly afterwards (1743) M. de la Condamine, while exploring the Marañon River, found the Omagua Indians living at a village near the mouth of the Rio Napo making use of two narcotic plants:

> One called by the Spaniards *floripondio* [*Datura arborea*], with flowers shaped like a drooping bell, which has been described by Père Feuillée; the other in the native vernacular called *curupa*, both of them purgatives. They cause intoxication lasting 24 hours, during which it is pretended that they have strange visions. The *curupa* is taken

[9] GUMILLA, JOSEPH. El Orinoco Ilustrado, pp. 117–118. 1741.

in the form of powder, as we take tobacco. but with more apparatus. The Omaguas make use of a cane tube terminating in a fork, of a Y-shaped form, each branch of which they insert into one of their nostrils. This operation, followed by a violent inspiration, causes them to make diverse grimaces.[10]

This snuff, called *curupa* and also, according to Gilii, *curuba*.[11] was afterwards identified by Humboldt with the *yupa* or *ñupa* of the Otomac Indians, described by Gumilla, and the *paricá* of Brazil,[12] and traced to a tree, which he called *Acacia Niopo*. Humboldt states that the missionaries on the Orinoco commonly call it tree-tobacco (*tabac en arbre*) to distinguish it from the ordinary herbaceous tobacco (Nicotiana).

FIG. 2. Bifurcated tube for snuffing powdered seed of *Piptadenia peregrina*. Used by Otomac Indians of the Orinoco River. Berlin Museum. Scale ½.

HUMBOLDT'S DESCRIPTION

Humboldt, who observed a party of Otomac Indians at Urana, a mission on the Orinoco River, says of them:

> . . . . they throw themselves into a peculiar state of intoxication, one might almost say of madness, by the use of the powder of *niopo*. They gather the long pods of a Mimosacea, which we have made known under the name *Acacia Niopo*, cut them to pieces, moisten them, and cause them to ferment. When the softened seeds begin to turn black they are ground into a paste, and after having mixed with them some flour of cassava and some lime made from the shell of an Ampullaria, they expose the whole mass to a very brisk fire, on a gridiron of hard wood. The hardened paste is given the form of little cakes. When wanted for use it is reduced to a fine powder, and placed on a dish five or six inches wide. The Otomac holds this dish, which has a handle, in his right hand, while he inhales the *niopo* by the nose, through a forked tube of bird's bone. This bone,

[10] See, *Relation abrégée d'un voyage fait dans l'intérieur de l'Amérique méridionale*, etc. par. M. de la Condamine, in Mém. de l'Acad. Roy. des Sciences, Année 1745, p. 428. Paris, 1749.

[11] GILII, F. S. Saggio de storia Americana, **1**: 201–202. 1780.

[12] HUMBOLDT & BONPLAND. Voyage aux regions équinoxiales, **2**: 620. 1819.

without which the Otomac believes he could not take this kind of snuff, is seven inches long: it appeared to me to be the leg-bone of a sort of plover.

A snuffing tube of the Otomac Indians, corresponding to this description of Humboldt and now in the Berlin Museum, is shown in the accompanying illustration, drawn by Mrs. R. E. Gamble after Max Uhle (fig. 2). Its form is closely similar to that of the polished wooden tubes of the Tainos of ancient Haiti, as described by Las Casas.

RUBBER SYRINGES OF THE OMAGUAS

De la Condamine, after describing the use of narcotic snuff by the Omagua Indians of the Marañon, tells of their peculiar use of syringes of rubber (*Cahuchu*). It was from these Indians, he says, that the Portuguese of the Pará learned to make rubber "pompes ou seringues" which do not require a piston.

> They have the form of hollow pears, pierced with a little hole at their end, in which a tube of wood is fitted . . . . This instrument is much used by the Omaguas. When they assemble together for some fête the master of the house does not fail to present one, as an act of courtesy, to each one of the guests, and its use always precedes, among them, the repasts of ceremony.[13]

Why such a peculiar custom should have become established among these Indians seems at first inexplicable; but the testimony of other travellers shows that similar practices exist, or did exist, among other tribes inhabiting the shores of tributaries of the Amazon; and that for these injections not water was used, but an extract of the same narcotic seeds as those from which snuff was made.

ACCOUNT OF SPIX AND MARTIUS

After describing the use of *paricá* snuff by the Mura Indians of the Rio Negro, Spix and Martius, in the narrative of their travels, tell of a custom of these people, during their strange annual assemblies which last eight days and are accompanied by all sorts of debauchery, of taking a decoction of *paricá* in the

[13] De la Condamine, in Mém. de l'Acad. Roy. des Sciences, Année 1745, pp. 430–431. 1749.

form of an enema: "Ein anderer Gebrauch des *Paricá* ist, einen Absud davon sich selbst als Klystier zu geben." Administered in this way, they say, the narcotic effect of the *paricá* is similar but weaker than when taken in the form of snuff. Commenting upon the custom, they continue:

> Man kann nicht umhin, durch diese viehische Lustbarkeit an die eckelhafte Sitte der Ostiaken und Kamtschadalen erinnert zu werden, welche sich bekanntlich durch den Genuss des Fliegelschwammes [*Amanita muscaria*] . . . . zu einer ähnlichen Wuth erhitzen.[14]

ROBERT SOUTHEY'S ACCOUNT OF PARICÁ SNUFF

The Mura Indians of the Rio Negro, instead of Y-shaped tubes, made use of tubes of another form, by means of which the men, in pairs, blew the snuff into each other's nostrils. The following description, published in 1819 by Robert Southey, was taken by him from the MS. of P. Joam Ribeiro:

> Some of the Rio Negro tribes have an extraordinary and tremendous ceremony, for which a large house is set apart in all their villages. It begins by a general flogging, the men in pairs scourging and lacerating one another with a thong, and a stone at the end: this continues eight days, during which the old women, who, among the American savages, officiate at most works of abomination, roast the fruit of the Parica tree, and reduce it to a fine powder. The parties who had been paired in the previous discipline are partners also in the following part, each in turn blowing this powder with great force through a hollow cane into the nostrils of his friend. They then commence drinking; and the effect of the drink and the deleterious powder is such, that most of them lose their senses for a time, and many lose their lives. The whole ceremony continues sixteen days: it is observed annually, and is called the feast of the Parica.[15]

IDENTITY OF TREES YIELDING SNUFF

In early descriptions of *cohoba* snuff of Hispaniola there is nothing to indicate the nature of the plant producing it. Oviedo, as we have seen, confused it with tobacco. On the other hand nearly all the descriptions of similar snuff used by South American Indians pointed to a mimosaceous tree bearing algaroba-like pods as its origin. Humboldt, as cited above, described the *yupa*, or *niopa*, as an Acacia; Spix and Martius, in the narrative

[14] Spix und Martius. Reise in Brasilien, **3**: 1075. 1831.
[15] Southey, Robert. History of Brazil, **3**: 722–723. 1819.

of their travels, referred to the *paricá* tree as a species of Inga; specimens collected by Schomburgk were described by Bentham under the name *Mimosa* (*?*) *acacioides*; Lieutenant Herndon, U. S. Navy, in the report of his exploration of the valley of the Amazon (1853) called it *Acacia angico*. Finally Bentham made a careful study of all the botanical material he could lay his hands on, and came to the conclusion that all the South American trees above referred to as the source of narcotic snuff were probably one species, and were identical with Linnaeus' *Mimosa peregrina*, which was first described in 1737 from a seedling growing in the celebrated Clifford Garden in Holland. In studying the flowers of this tree Bentham came to the conclusion that it could be regarded neither as a true Mimosa nor as an Acacia, but that it must be placed in a closely related genus, which he called Piptadenia, and consequently, in accordance with the rules of priority, be called *Piptadenia peregrina*. In his synonymy he made no reference to the *cohoba* tree of Haiti and Porto Rico. In Martius's *Flora Brasiliensis* this and several very closely related species are set apart as a section of Piptadenia, called *Niopo*. It is quite possible that some other of these species, especially *Piptadenia macrocarpa* Benth., are also a source of narcotic snuff; and it is either this species or *P. peregrina* itself from which the Quichua Indians derived their intoxicating *huillca*, or *vilca*, with which, according to Acosta, they used to get gloriously drunk (*emborrachanse bravamente*).

SEBIL AND HUILLCA SNUFF OF ARGENTINA AND PERU

Still another very closely allied species of Piptadenia was described by Grisebach from specimens growing in the vicinity of Cordova, Argentina. A careful study of Grisebach's description inclines the writer to believe it possible that the plant in question, described by Grisebach first under the name *Acacia Cebil* and afterwards as *Piptadenia Cebil*, is a variety of *P. peregrina*, or of *P. macrocarpa*. Grisebach does not indicate the narcotic properties or indeed any uses of this plant, but in his first description he gives its vernacular name in Tucuman as *cebil*.[16] Of the

[16] See GRISEBACH, in Abhandl. der königl. Gesellsch. der Wissensch. zu Göttingen, **19**: 136. 1874; ibid., **24**: 121. 1879.

use of the fruit of this same tree for snuff we have an early account, written about the year 1583. In Pedro Sotelo Narvaez's *Relacion de las Provincias de Tucuman*, he says of the Indians living in the vicinity of Cordoba:

> They do not make such great use of *azua* (fermented chicha) as the Indians of Peru. They take through the nostrils the *sebil*, which is a fruit like the *vilca*; this they pulverize and inhale through the nostrils (*hácenla polvos y bébenla por las narices*).[17]

Vilca, also written *huilca*, or *huillca*, described by certain writers as little beans (*frisolillos que llaman vilca*), remained unidentified until very recently, although, as cited above, it was mentioned at a very early date by Acosta as an intoxicant used by the Quichuas. Specimens were secured by Mr. O. F. Cook, of the U. S. Department of Agriculture, from an Indian drug-vender in southern Peru, in 1915. They were labeled *huillca*, and proved to be seeds of a Piptadenia, if not identical with *P. peregrina*, at least very closely allied to that species.

FIG. 3. Snuffing tube of llama bone from Tiahuanaco, Bolivia. Philadelphia Museum. After Uhle. Scale ½

Huillca, like *cohoba*, *ñopa*, and *cebil*, was snuffed up by means of tubes. Max Uhle obtained a remarkable snuff tube, in all probability used in the process by the ancient Quichuas, at Tiahuanaco, Bolivia, in June, 1895. This tube (fig. 3) is now in the Philadelphia Museum of Science and Art (No. 36095). It resembles closely a specimen, recently discovered in a burial cave at Machu Picchu by the Peruvian Expedition sent out under the auspices of Yale University and the National Geographical Society.[18] The fork of the snuffing tube is formed by the bifurcation of the distal end of the metatarsus or leg-bone, of a llama. The Tiahuanaco specimen, finished and ornamented by incised carving, has been slightly chipped at the lower end; the Machu Picchu specimen, in the first stages of manufacture, has a trans-

[17] Relaciones Geograficas, Peru, **2**: 152. 1885.

[18] See, EATON, GEORGE F., in Mem. Conn. Acad. Arts and Sciences, **5**: 58, *pl. 4, fig. 8*. May, 1916.

verse cut across the bifurcation; this in all probability was intended to be cut off, so that the ends might fit the nostrils.

The Tiahuanaco specimen is described at length by Max Uhle, who published a photographic illustration of it,[19] from which the figure here shown was drawn. Uhle believed that this tube was used for snuffing tobacco; but this I think doubtful. Humboldt, as already quoted, says that Piptadenia was commonly called "tree-tobacco," and the custom of snuffing its powdered seeds was common among many tribes inhabiting the banks of the tributaries of the great rivers of South America, which extended to the boundaries of Peru and Bolivia; and we have the definite statement that the snuff made from the seeds of *P. Cebil* was quite similar to the *vilca* (or *huillca*) of the Peruvians.

In the paper above cited, Uhle recognized that *cohoba* snuff and tobacco had been confused by various authors, and even suggests the possibility of the common origin of the names *cohoba* and *curupa*, but he says nothing of the actual presence of *Piptadenia peregrina*, the true "tree-tobacco," in Hispaniola. It was not until the writer consulted Urban's recent work on the flora of the Antilles that he found mention not only of the tree itself but of the ancient name by which it was known to the aborigines of Hispaniola.[20] Urban, however, gives no hint of its former use as a source of snuff, or of the narcotic properties of its seeds.

BOTANICAL DESCRIPTION OF COHOBA

Piptadenia peregrina (L.) Benth. Journ. Bot. Hook., **4**: 340. 1842.
Mimosa peregrina L. Sp. Pl., 1504. 1753. (*Mimosa inermis*, etc. Hort. Cliff. 209. 1737.)
Inga Niopo Willd. Sp. Pl., **4**: 1027. 1806.
Acacia peregrina Willd. Sp. Pl., **4**: 1073. 1806.
Acacia microphylla Willd. Sp. Pl., **4**: 1073. 1806.
Mimosa Niopo Poir. in Lam. Encycl. Suppl., **1**: 48. 1810.
Acacia Niopo Humb. & Bonpl., Relation Hist., **2**: 620–623. 1819; H. B. K., Nov. Gen. et Sp., **6**: 282. 1823; Kunth, Synop. Pl., **4**: 20. 1825.
Acacia angustiloba DC. Prodr., **2**: 470. 1825.
Mimosa (?) *acacioides* Benth. Journ. Bot. Hook., **2**: 132. 1840.
Piptadenia Niopo Spruce, Notes of a Botanist, **2**: 426. 1908.

[19] See, Bull. Mus. Science and Art, University of Pennsylvania, Vol. 1, No. 4. 1898.

[20] URBAN, I. Symbolae Antillanae, **4**: 269. 1905.

Piptadenia peregrina is a Mimosa-like shrub or a tree reaching the height of about 60 feet, with a trunk about 2 feet in diameter. The bark is often more or less muricated, but the branches and leaves are unarmed. The leaves are bipinnate, resembling those of many Acacias and Mimosas, with 15 to 30 pairs of pinnae and very numerous minute leaflets (30 to 80 pairs), these linear in shape and apiculate at the apex. On the petiole at some distance from the base there is a conspicuous oblong nectar-gland and on the rachis, between the last pair or last two or three pairs of pinnae, there is usually a minute gland, as in many of the Mimosaceae. The inflorescence is in the form of spherical heads of minute white flowers, borne on long slender peduncles in terminal or axillary racemose clusters. As seen under the lens the calyx and corolla are both 5-toothed, the former campanulate, the latter connate to the middle. The 10 stamens are free, much exserted, the anthers at anthesis bearing a minute stipitate gland. The ovary contains several to many ovules, and develops into a broadly linear, flat, leathery, or woody 2-valved legume, rough on the outer surface and thickened along the sutures, and resembling that of an Inga, but without pulp surrounding the seeds. The seeds are flattish and orbicular, greenish at first, at length black and glossy.

So far as the writer can ascertain, no figure of this species has hitherto been published. The accompanying illustration (fig. 1) is from a photograph of a specimen in the U. S. National Herbarium (No. 847320), collected on a hillside near Mayagüez, Porto Rico, in March, 1906, by John F. Cowell (No. 630).

GEOGRAPHICAL DISTRIBUTION

Piptadenia peregrina has a most appropriate specific name, for it has a wide geographical range. This has undoubtedly been increased by human agency. Various travellers have noticed it planted near villages, as well as growing spontaneously in the forests bordering the great rivers of South America. It was in all probability carried to Haiti and Porto Rico by the ancestors of the Tainos, whom Columbus found inhabiting those islands. Including with it the very closely allied *Piptadenia macrocarpa* Benth. and *P. Cebil* Griseb., its distribution may be roughly indicated as follows:

HAITI, or HISPANIOLA, where according to Ramon Pane and Las Casas, it was called *cohoba,* or *cogioba;* PORTO RICO, where it is still called *cojoba* or *cojobo* (Urban), or *cojobana* (Cook and

Collins); VENEZUELA, where it is called *curuba, ñupa, ñopa, niopa, niopo* (Gumilla; Gilii; Humboldt); NORTHEASTERN PERU, on the Marañon, where it is called *curupa* (de la Condamine); SOUTHERN PERU, where it is called *vilca, villca, huillca* (Acosta; O. F. Cook); ARGENTINA, where it is called *cebil*, or *sebil* (Grisebach; Sotelo Narvaez); GUIANA, where two varieties are found, *paricá* and *black paricá* (Schomburgk); BRAZIL (many parts), where it is generally known as *paricá* (Spix and Martius; Lieutenant Herndon; Spruce).

CHEMICAL PROPERTIES AND PHYSIOLOGICAL ACTION

The most remarkable fact connected with this narcotic is that its chemical properties are still unknown. An exhaustive search through literature, in a vain attempt to find something bearing upon the subject, indicates that it has never been studied chemically or therapeutically. The only authority who mentions it is Dragendorff, who dismisses it with the statement: "Der Same zu Schnupftabak (Niopo, Nupa), der stark aufregen soll, verwendet." No authority is quoted, except for the botanical name and its synonyms. This may have been in consequence of the remark Humboldt made in connection with the snuff:

> La famille des Légumineuses varie singulièrement dans les propriétés chimiques et médicales de ses graines, de ses sucs et de ses racines; et quoique le suc du fruit du *Mimosa nilotica* soit très-astringent, on ne peut croire que ce soit principalement la silique de l'*Acacia Niopo* qui donne la force excitante au tabac des Otomaques. Cette force est due à la chaux fraîchement calcinée."[21]

That Humboldt was mistaken is indicated by Spruce's observations. Moreover it is not so strange, as Humboldt would indicate, that the seeds of certain Leguminosae have narcotic properties. The red seeds of *Sophora secundiflora* of Texas and northern Mexico are very narcotic and are still used by certain Indian tribes to cause intoxication. They are used in certain secret ceremonies by the "Red Bean Society" of the Iowa Indians, which takes its name from them. Spruce witnessed the preparation of *ñopa* snuff without the addition of lime, in June, 1854, by a party of Guahibo Indians from the Rio Meta, temporarily

[21] HUMBOLDT & BONPLAND. Voyage aux regions équinoxiales, **2**: 621. 1819.

encamped near the cataracts of the Orinoco. In his account of it he says: "In the modern *niopo*, as I saw it prepared by the Guahibos themselves, there is no admixture of quicklime, and that is the sole difference [from the method of its preparation described by Humboldt]." He describes the process of roasting and powdering the seeds, and the snuff-tube made of the leg bones of birds, shaped somewhat like a tuning fork, with the forked ends tipped with small black knobs (the endosperms of a palm). This instrument, which he secured and deposited in the Museum of Vegetable Products at Kew, is almost identical in form with that of the Otomac Indians in the Berlin Museum (fig. 2), and also very much like the one used in ancient Haiti, so accurately described by Las Casas and incorrectly figured by Oviedo.

SUMMARY

Cohoba, a narcotic snuff which the aboriginal inhabitants of Haiti took by means of a bifurcated tube, has hitherto been regarded by most writers as a form of tobacco. It was, however, prepared from the seeds of a Mimosa-like tree, *Piptadenia peregrina*. This tree is widely spread in South America, and by several tribes of Indians its seeds are used, or have been used until recently, as a source of snuff, the effects of which are highly intoxicating. Among several of these tribes the snuffing tubes are bifurcated and very similar to those of the ancient Haitians. The source of the snuff on the island of Haiti has remained unknown for so long a time on account of the early annihilation of the aborigines and their replacement by Africans, who did not adopt the habit of snuffing. The most remarkable fact connected with *Piptadenia peregrina*, or "tree-tobacco," is that, though its fruit has been reported by many explorers and botanists as highly narcotic, it has never been studied chemically or therapeutically, and the source of its intoxicating properties still remains unknown. Abundant material may be obtained from the island of Porto Rico, where the tree is common, and it is hoped that a careful study may be made of the seeds, the peculiar properties of which were noticed in the very first work which treated of the ethnology of the New World.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*Wheatstone bridges and accessory apparatus for resistance thermometry.* E. F. MUELLER. Bureau of Standards Scientific Paper No. 288 (Bull. Bur. Stds., **13**: 547). 1916.

A type of Wheatstone bridge, suitable for use in resistance thermometry, has been developed, in which plugs or dial switches are used, and the circuits so arranged that the errors due to contact resistances are no greater than with the mercury contact bridges heretofore used. With a comparatively simple and inexpensive type of apparatus it has been possible to attain the high degree of precision and accuracy demanded in modern work with resistance thermometers.

A method of measuring potential terminal resistances by the Wheatstone bridge method is also given, and the necessary accessory apparatus for this purpose is described. E. F. M.

PHYSICS.—*The damping of waves and other disturbances in mercury.* M. H. STILLMAN. Bureau of Standards Scientific Paper No. 289 (Bull. Bur. Stds., Vol. 13). 1916.

In instruments involving the use of mercury, the waves and other disturbances, produced by the unsteadiness of the containing vessel, are a frequent source of trouble. If the mass of mercury be subjected to a strong magnetic field, the direction of the field being approximately at right angles to the direction of motion of the mercury, these motions will be strongly damped.

The substitution of a non-magnetic metallic container for a glass container greatly increases the magnitude of the damping.

It is suggested that this method might sometimes be used when it is desired to obtain accurate adjustments of mercury surfaces at sea and in other places where unsteadiness of the mercury container is unavoidable. M. H. S.

GEOLOGY.—*The flora of the Fox Hills sandstone.* F. H. KNOWLTON. U. S. Geological Survey Professional Paper 98–H. Pp. 8, with one illustration. 1916.

The known flora of the Fox Hill sandstone includes only thirteen forms. Of these it appears that only four of the species have been previously known, the remainder being new to science or so fragmentary as not to merit specific designation. This little Fox Hills flora shows distinctly Upper Cretaceous affinities, being, as might be presumed from its stratigraphic position, intermediate between the older floras of the Montana group and the younger flora of the overlying Laramie, but having a preponderance in its resemblances to the Montana. Ecologically this flora appears to indicate a much more abundant supply of moisture than now exists in the region, though this should naturally follow from the fact that it must have been growing near the sea and not far above sea level. The meager data appear to indicate a warm-temperate climate. Descriptions of the species are given together with illustrations. R. W. S.

GEOLOGY.—*The fauna of the Chapman sandstone of Maine, including descriptions of some related species from the Moose River sandstone.* H. S. WILLIAMS, assisted by C. L. BREGER. U. S. Geological Survey Professional Paper 89. Pp. 347, 27 plates, 3 figs. 1916.

The Chapman sandstone is exposed over a small area in Chapman Township, Aroostook County, Maine. It includes at least 500 feet of medium, fine grained, brown to gray sandstone, much of it thick bedded, with some fine grained shaly layers separating the beds. In these shaly sandstones occur most of the fossils which are marine. Here and there fragments of plants appear in the sandstone. In the supposedly overlying Mapleton sandstones only plant fossils have been discovered. A detailed study of the fauna described in this volume demonstrates its general affinity with the later phase of the American Helderbergian fauna. Several species from the Moose River sandstones are mentioned and figured, from which it is evident that this Moose River sandstone is roughly equivalent to the Oriskany sandstone of New York and the York River of Gaspe Peninsula. The evidence is clear that the Chapman forms, closely related to the Moose River species, are earlier representatives of the evolutional lines to which they belong than the Moose River forms. This report contains, besides the detailed descriptions of many genera, 27 plates depicting hundreds of fossils. R. W. S.

GEOLOGY.—*Revision of the Beckwith and Bear River formations of southeastern Idaho.* G. R. MANSFIELD and P. V. ROUNDY. U. S. Geological Survey Professional Paper 98–G. Pp. 9, with illustrations. 1916.

It has been found necessary to apply new names to strata hitherto referred to the Beckwith and Bear River formations or to portions of the Laramie as mapped by the Hayden Survey. The formations discussed extend from the northeastern part of the Montpelier quadrangle northward through the eastern part of the Wayan quadrangle and thence northward an undetermined distance, possibly including a considerable part of the Caribou Range. They include about 17,000 feet of strata, unless there are unrecognized repetitions by folding or faulting. The strata in this area that were formerly called the Bear River are here assigned to the Wayan formation, of Cretaceous, possibly Lower Cretaceous, age, and the so-called Beckwith is divided into seven formations, of which the lower two are marine formations of Jurassic age, and the remaining five are nonmarine formations assigned to the Ganett group, of Cretaceous (?) age. This paper gives a statement of the stratigraphic problems involved and a description of the formations.

R. W. S.

GEOLOGY.—*The Yukon-Koyukuk region, Alaska.* H. M. EAKIN. U. S. Geological Survey Bulletin 631. Pp. 85, with maps, sections, and view. 1916.

The Yukon-Koyukuk region lies in central Alaska and is drained by the two rivers from which it takes its name. Most of its relief is low, but locally there are northeasterly trending mountain ranges (5000–6000 feet). The predominant type of topography consists of rolling, maturely dissected uplands of moderate relief broken by extensive lowlands. The timber is chiefly spruce and birch, and timber line is at an altitude of about 2000 feet. Meadows of luxuriant growths of grass break the timbered areas.

The bed rock consists of metamorphic sediments (Paleozoic or older), greenstones (Post Devonian?), and more extensive areas of conglomerates, sandstones and shales probably chiefly of Upper Cretaceous age. Two epochs of granitic intrusion are recognized. The older granites cut the metamorphic series and are more or less altered while the younger granite is intruded into the Cretaceous and is in most places entirely massive. There is some auriferous mineralization along the margins of the younger intrusive masses. The Quaternary is repre-

sented by the alluvium of the lowlands and valleys, by high gravel and silt terraces, and in the higher mountains by local glacial deposits. The metamorphic series is intensely deformed and the Cretaceous strata also exhibit complex structures.

There is clear evidence that very extensive changes of drainage have taken place during Quaternary times. This is believed to have been due to the advance of glaciers from the mountains which bound the central Yukon region. The terraces are believed to have been formed in lakes caused by ice damming. A. H. B.

GEOLOGY.—*Natural gas resources of parts of North Texas.* E. W. SHAW, et al. U. S. Geological Survey Bulletin 629. Pp. 129, with maps, sections and illustrations. 1916.

The examination on which this report is based was instigated by the citizens of Dallas and Fort Worth, for the purpose of getting information as to the sufficiency and the prospective duration of the gas reserves within reach of these cities. The two reports contained in this volume describe not only the geology of several gas fields but also discuss the original quantity of the gas, the present capacity and the probable life of the fields. Areas that are worthy of prospecting with the drill are pointed out and it is concluded that the Petrolia field from which the present supply is being drawn would last the cities only 3 or 4 years. The other known pools of Texas being small it becomes necessary either to discover new gas pools or to lay pipe lines to those of Oklahoma. E. W. S.

GEOLOGY.—*Petroleum withdrawals and restorations affecting the public domain.* MAX W. BALL. U. S. Geological Survey Bulletin 623. Pp. 427, with 9 maps. 1916.

This bulletin contains true and accurate copies of orders of withdrawal, restoration, modification and classification and of the more important correspondence leading to changes of policy regarding these; an index to the orders, township by township; a short statement of the purpose of the withdrawal policy; and a brief review of the history of oil withdrawals. In addition, it includes a chapter on oil-land law, giving the statues and decisions, judicial and departmental, which may be of most interest to the oil operator on the public domain. It is accompanied by maps showing the areas withdrawn in each state—Arizona, California, Colorado, Louisiana, Montana, North Dakota, Utah, and Wyoming—where oil withdrawals were outstanding January 15, 1916). R. W. S.

GEOLOGY.—*The physical conditions indicated by the flora of the Calvert formation.* E. W. BERRY. U. S. Geological Survey Professional Paper 98-F. Pp. 12, with illustrations. 1916.

This paper gives a summary of the small flora preserved in the Miocene diatomaceous beds of the Calvert formation in the District of Columbia and Virginia, and discusses its bearing on the physical conditions of the Calvert epoch. It is concluded that the Calvert flora was coastal flora of strikingly warm-temperate affinities, comparable with the existing coastal floras of South Carolina and Georgia, or with those along the coast of the Gulf of Mexico from western Florida to eastern Texas. The climate of the Chesapeake Miocene epoch,cooler undoubtedly than that of the Apalachicola or preceding epochs, was neither cold nor cool-temperate. The age indicated by the Calvert flora is middle Miocene. R. W. S.

GEOLOGY.—*Antimony deposits of Alaska.* ALFRED H. BROOKS. U. S. Geological Survey Bulletin 649, Pp. 64, with maps. 1916.

Stibnite is widely distributed in Alaska having been found in 67 localities. In many of these it occurs simply as an accessory mineral, but lodes have been found in the Fairbanks, Kantishna, Innoko, Iditarod, Nizina, and Port Wells districts and on the Kenai and Seward peninsulas in which stibnite forms the principal metallic mineral.

The country rock of the stibnite lodes is sedimentary as a rule, but differs greatly both as to age and lithology in the different districts. Some deposits have been found in highly metamorphosed schists of pre-Cambrian age. Others are found in little-altered clastics, as young as Upper Cretaceous. Practically all the antimony lodes occur in association with granular acidic intrusive rocks, among which the dominating lithologic types have been described as quartz diorite and monzonites.

The Alaska antimony deposits may be classed in three principal groups—siliceous gold-bearing stibnite lodes, stibnite-cinnabar lodes, and stibnite-galena lodes. Of these the first two can be further divided according to structure as fissure veins, shear-zone deposits, and stockworks.

The evidence at hand indicates that most of the stibnite deposits were formed at a later time than the widespread epoch of Mesozoic mineralization to which so many of the gold deposits have been assigned. Formerly it was generally believed that nearly all the metalliferous deposits of Alaska were associated with Mesozoic intrusives. It is

only in recent years since the metalliferous deposits of the lower Yukon and Kuskokwim regions have been studied that the importance of the Tertiary period of mineralization has been recognized. Localities in this general province as widely separated as the lower Kuskokwim and northern British Columbia are now known to have been mineralized in Tertiary time, but between these localities there are mining districts in which the metallization is of Mesozoic age. Thus there seems to be here an overlapping of the two metallogenetic provinces. Like the Mesozoic mineralization, that of Tertiary age is genetically connected with granular acidic intrusive rocks, but the later intrusives seem to have been less widely distributed than the earlier.

It should be noted that though mineralization accompanied the Tertiary intrusives, no metalliferous lodes have been found in the Tertiary sediments. It appears that the conditions for the formation of the metalliferous veins necessitated a deeper cover than that furnished by these beds. A. H. B.

ENGINEERING.—*Surface water supply of the United States, 1914. Part III. Ohio River Basin.* NATHAN C. GROVER, et al. U. S. Geological Survey Water-Supply Paper 383. Pp. 121, with two illustrations. 1916.

This volume is one of a series of reports presenting results of measurements of flow made on streams in the Ohio River Basin during the year ending September 30, 1914. It includes also a list of the stream gaging stations and publications relating to water resources in this Basin. O. E. M.

TECHNOLOGY.—*The correlation of the mechanical and magnetic properties of steel.* CHAS. W. BURROWS. Bureau of Standards Scientific Paper No. 272, pp. 173–210. 1916.

This paper is a review of the work done in correlating the magnetic and mechanical properties of steel with special reference to the commercial application of the magnetic data as criteria of the mechanical fitness of a given steel and of magnetic changes under stress as indications of the state of strain. C. W. B.